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ABUNDANCE AND CONSERVATION OF THE BOB-WHITE IN OHIO.*

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INTRODUCTION.

Ever since the eastern bob-white or quail, *Colinus virginianus virginianus* (Linnaeus), was put on the protected "song-bird list" in Ohio in 1917, after annually closed hunting seasons since 1913, there has been considerable discussion and agitation among sportsmen to have it recognized again as a game bird. Frequent attempts to introduce legislation in the Ohio Assembly, for having an open hunting season again put on the species, have been frustrated up to the present. The question has caused so much feeling between factions that a permanent settlement to the satisfaction of both sides of the controversy is very desirable, if it prove practicable. It is hoped that the present paper will contribute towards that end.

ESTHETIC AND ECONOMIC IMPORTANCE.

The bob-white is a very attractive and beautiful bird with a loud cheery song, and has endeared itself to all lovers of nature and to country folk in general. Many urge the complete protection of the species in the State on this basis alone.

The intelligent farmer has good reason to wish that the species be maintained in its normal numbers. The studies of Judd (1903, 1905), Nice (1910), and others show beyond doubt that the bird has great value as a destroyer of weed seeds and insects. Some 60 different species of weed seeds and 116 species of insects are consumed as food. Among the insects occur such distinctly undesirable forms as chinch bug, potato beetle, and striped cucumber beetle. The species consumes some grain, but this seems to be largely waste grain that remains after the crop has been harvested.

*Contribution from the Baldwin Bird Research Laboratory (No. 25) and Western Reserve University, Cleveland, Ohio.

IMPORTANCE AS A GAME BIRD.

The bob-white undoubtedly makes a fine game species in areas where it is sufficiently abundant. The hunting of bob-white is a sport of high order, since it demands skill, training, and patience, and requires a hardiness and love of the out-of-doors that may well be encouraged.

BASIS FOR CONSERVATION.

The above discussion shows that the bob-white is of legitimate interest to the lovers of nature, to the farmer, and to the sportsman. Can conservation of this species be based upon measures that will permit the realization of all these interests? This realization is possible only if the greatest care be taken to consider the safety of the bird as a species and the maintenance of a large number of individuals all over the State. One of the first studies that needs to be made in this connection is the determination of the actual population of the bird and the factors that are responsible for increasing and decreasing its numbers.

CENSUS-TAKING.

Since 1901, there have been reported annually in *Bird-Lore* magazine the results of one-day censuses of all species of birds, taken between December 22 and 27 by observers located all over the country. Since 1908 the number of census reports from Ohio have been sufficient to make possible some estimation of the number of bob-white present during this time of the year. These records have been compiled for the years 1908 to 1931, inclusive, with the results shown in Table I.

In arriving at an estimation for the total population of bob-white in Ohio, various factors must be considered. The total number of reports for different localities is not so important as the number of parties making these reports. It is necessary, in order to judge the amount of territory that was covered in the census, to determine the average number of miles traveled by each party per hour in the field for each year separately. A difficulty arises as to the width of this strip of territory over which the census-taker could have made an accurate count of the bob-white present. With some hesitation, this was estimated to be about 75 feet. Using this figure and knowing the average mileage covered per hour, the square mileage of

territory covered could be figured. A correction of this figure must next be made for the number of people making up the party. The average number of people per party ranged from 1.2 in 1908 to 2.4 in 1931. It is assumed that two people in a party will be approximately twice as efficient in making a census of bob-white as will one. This may not be strictly true in some cases, but seems to be the only legitimate way,

TABLE I.

TOTAL POPULATIONS OF BOB-WHITE IN OHIO DURING LAST 24 YEARS, ESTIMATED FROM BIRD-LORE CHRISTMAS CENSUS REPORTS.

Year	Total Number of Parties Reporting	Total Populations, Uncorrected	Total Populations, Corrected from Figure 1
1908	15	1,343,000	1,700,000
1909	10	814,000	600,000
1910	16	1,800,000	1,350,000
1911	21	1,128,000	1,500,000
1912	24	521,000	900,000
1913	12	345,000	650,000
1914	16	1,710,000	950,000
1915	16	349,000	1,200,000
1916	12	2,395,000	1,500,000
1917	11	369,000	1,000,000
1918	8	592,000	1,000,000
1919	14	2,706,000	1,800,000
1920	16	1,350,000	2,600,000
1921	17	2,549,000	3,500,000
1922	23	5,496,000	4,000,000
1923	16	2,506,000	4,100,000
1924	19	5,740,000	4,100,000
1925	24	5,008,000	3,700,000
1926	26	2,369,000	3,100,000
1927	34	3,561,000	2,500,000
1928	27	997,000	2,000,000
1929	33	3,018,000	2,000,000
1930	44	3,553,000	2,550,000
1931	42	2,307,000	3,350,000

without careful field tests, in which a correction may be made for the size of the party. The square mileage of territory covered per party is multiplied, therefore, by the average number of people constituting the parties during that year. Knowing the total square mileage in the State, the percentage of this area covered by a party of census-takers during an hour can then be determined.

The next step in this computation consists in figuring for each year separately the average number of bob-white seen

per party per hour in the field. When this is known, and the percentage of the total area of the State that is covered is known, the total population of bob-white may be readily computed. These are the figures given in Table I.

In this method of computation the attempt is made to eliminate, as far as possible, errors dependent upon variations in the human equation. Census-takers undoubtedly select their routes in order to get the largest possible number of birds of all species. Such a route may be at times through habitats where bob-white are most abundant, as along fences, hedge-rows, forest edges, etc.; but at other times this route will traverse woods, village streets, and other localities ill-adapted for bob-white. As areas unfavorable for birds of all

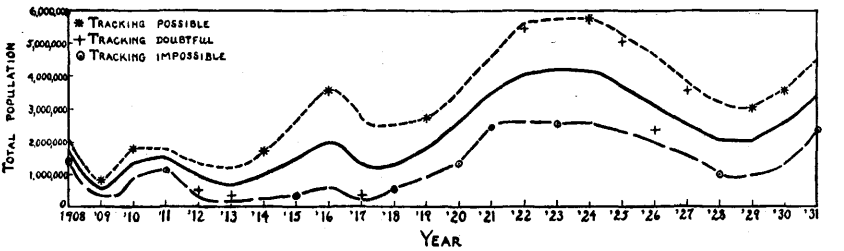

FIGURE 1. FLUCTUATIONS IN ABUNDANCE OF BOB-WHITE IN OHIO FROM 1908 TO 1931. The asterisk marks years with sufficient snow on ground to make tracking of birds possible; the cross marks years when the ground was only partially or lightly covered with snow so that tracking may or may not have been possible; and the circle marks years when the ground was bare so that tracking was impossible. Broken lines connect years when tracking was possible and years when tracking was impossible. The full continuous line represents the median and probably most accurate estimation of the total annual populations.*

species, including the bob-white, are generally avoided, estimates of total bob-white population based on these censuses will tend to be high. This is counteracted in part by the fact that census-takers do not use trained bird dogs, so that some bob-white in the most favorable places are undoubtedly missed. By giving each census-taker credit for covering a rather broad area of 75 feet on his trips, even when two or more persons take the census together, it is believed that the unfavorable "blank" spaces are accounted for.

Another possible source of error in these figures of total population lies in the effect which the weather on the day that the censuses were taken has on the number of bob-white

*An error in the population data for 1916, found when reading proof, is corrected in Table I.

recorded. A compilation was therefore made of temperature, cloudiness, wind, precipitation, and amount of snow on the ground on the days that the censuses were taken. None of these factors except the last appeared to affect the numbers of bob-white recorded. In a personal communication, Stoddard emphasized the importance which the amount of snow on the ground may have on the records obtained. When the ground is covered with snow, tracks of the bird may be readily found and easily followed so that it is logical to expect a larger number of birds to be recorded during those years than during years when the ground is bare. The importance of this factor is shown in Figure 1.

The actual figures of total bob-white population, as determined by the methods above described, were first plotted in Figure 1. Then the years were marked according to whether tracking was possible, doubtful, or impossible. The figure then showed clearly that many more birds were recorded during years with snow on the ground than during years when the ground was bare. A line was then drawn connecting the figures for those years with snow and another line connecting the figures for the years without snow. In general, the trends in fluctuation of population are very similar regardless of which curve is taken. Finally, a medium curve was drawn halfway between the other two. Probably this more nearly represents the actual total bird population in the State than does either of the two extremes. The corrected total population given in Table I are figures read from this medium curve in Figure 1 for the corresponding years. We would judge these figures to be accurate to within 25%, but whether or not they are this accurate must wait and be checked in the future by intensive field work over corresponding years. The *Bird-Lore* censuses are admittedly not all that might be desired to serve as a basis for an estimation of total population of birds, but furnish the only information available for the past two dozen years.

AVERAGE ABUNDANCE.

The average abundance of the bob-white in Ohio during the last 24 years is 2,152,000 birds, or one bird to approximately 12 acres. Since the species has been given continuous protection since 1913, the average abundance of the species may be figured from 1913 to 1931, inclusive. This is 2,400,000 birds, or one bird to 10.9 acres. The greatest abundance which is

recorded for the species during any year in this 24-year period is 4,100,000 in 1923 and again in 1924. This is one bird to 6.4 acres. The number of birds per acre would average higher if only agricultural land with favorable habitats were included instead of taking the whole area of the State. Undoubtedly also, the species varies in abundance locally in different parts of the State, being less abundant in some regions and more abundant in others.

Leopold (1931) found that one bird on two to four acres of farming land is the most frequent density of population in the north central states, with one bird on four to eight acres ranking a close second. One bird per acre is believed to be the "saturation" point of greatest possible abundance of bob-white. In "natural" areas of Florida, Stoddard (1931) found one bird on four to five acres. Likewise, on many preserves in southern Georgia, Stoddard found only one bird on four to five acres, while on others he found one bird on two acres, and on the best developed acres, one bird per acre.

FLUCTUATIONS IN ABUNDANCE.

In southern Georgia, Stoddard (1931) found that the bob-white population was essentially stable from year to year with no evidence of regular cyclic fluctuation in numbers. Variations of abundance occurred, but never exceeded 50%. The rather stable nature of the bob-white population in the south may be due, in part, to the absence of severe winter weather, particularly to the absence of snow.

Leopold (1931) has discussed in detail the abundance of bob-white in Minnesota, Wisconsin, Michigan, Iowa, Missouri, Illinois, Indiana, and Ohio. He likewise states that the quail population is very stable except along the very northern borders of the species' range. The recollections of local sportsmen, which Leopold compiled, show low numbers of birds in parts of Ohio in 1887, 1891, 1901, 1923, and 1928, and all over Ohio in 1918. The average interval between these seven known periods of scarcity is seven years in Ohio. In nearby states the period ran from four to seven years.

The curve of abundance of bob-white in Ohio based on the *Bird-Lore* census reports (Figure 1) shows low points in 1909, 1913, 1917–1918, and 1928–1929. The low point of 1909 is not well established, since it is based on records of only one year. This agrees with the findings of Leopold for low numbers

of birds in Ohio in 1918 and 1928, but does not agree with his report of low numbers in 1923, when this curve reaches its highest point.

Figure 1 shows that the bob-white reached peaks of abundance in 1911, 1916, and 1922–1924. The species was more abundant in 1922–1924 than in either of the other two peaks.

The time intervals between the low points in the curve of abundance are approximately 4, 4½, and 11 years, respectively. The time intervals between the peaks of abundance are approximately 5 and 7 years, respectively. This evidence is not sufficient to indicate that there are definite cycles in the abundance of the bob-white but does show that considerable fluctuations in abundance occur.

INBREEDING AND OUTBREEDING.

There is a widespread opinion among sportsmen that bob-white will decrease in size, vigor, and abundance through inbreeding, if the coveys are not scattered by shooting. In contradiction to this idea are the statements of some of the leading students of bob-white in America. Leopold (1931, page 54) states, "In short, there is not a shred of real evidence that quail inbreed if unshot, or that it would hurt them if they did." People apparently forget that the bob-white existed and thrived for ages before the advent of the white man and the shot-gun without ill effects resulting.

Stoddard (1931) has studied the question of inbreeding in bob-white. He states that hunting does increase, to some extent, the shifting of birds from one covey to another, but that the increased shifting due to this cause is not so much as might be expected, nor is the shifting and intermingling of birds from one covey to another dependent on hunting. There is some tendency for mating in the spring to take place between members of the same covey, but the covey is not a family group. The covey is made up of members of several different broods and of surplus cocks and unattached individuals. He found, through banding operations, that there is a shuffling of birds between coveys before mating begins regardless of whether or not there is hunting.

Dr. Baldwin, of our laboratory, is positive in stating that shooting does not break up coveys of bob-white as long as a sufficient nucleus of birds remains. Dr. Baldwin has spent

considerable time in the field in southern Georgia during the last thirty years, and was, in fact, responsible in large measure for organizing the Quail Investigation there under the able leadership of Mr. H. L. Stoddard. He makes this comment upon the subject of breaking up coveys and inbreeding:

"A number of the sportsmen, subscribers to the Quail Investigation, were either near friends of mine or members of my family, so that during each winter season I made many trips with them into the quail fields shooting with gun or camera. Most often I went with a nephew who had some fifteen thousand acres of quail fields and had been accustomed for many years to take about 1,000 quail each year from that area. His game keeper, Jim, was famous in that part of Georgia for his knowledge of the game and his ability to know each covey of birds in this entire area and, at will, to locate the covey and remember the exact number of birds in the covey. It was the daily experience to plan with Jim just what portion of the fields would be hunted for that day, and just what coveys would be gotten up. Jim would tell with extraordinary accuracy just how many birds were left in a certain covey when it was last shot out, and when the covey was flushed that number of birds would get up; or at times if birds were missing, it was judged and sometimes afterwards proven that poachers had been into the covey. So accurate were these observations as to number of birds, and so well could the numbers be traced throughout the winter that it was preposterous to say that coveys were broken up by shooting. Indeed this old tradition about breaking up coveys by shooting to prevent inbreeding was discussed and at times we would get up coveys on succeeding days on purpose to note that the numbers closely tallied with the number of birds left when last shot out. One who remains in the vicinity for a few hours after the covey is shot out will see the birds gather into a covey again, and usually no bird has been driven so far as into the territory of the next covey. The tradition that the health of the birds is improved by breaking up coveys in order to prevent inbreeding is subject to fatal criticisms."

East and Jones (1919) have discussed in detail the genetics of inbreeding and outbreeding among all sorts of animals and plants. They maintain that inbreeding in itself is not deteriorating to a race, but that it may weed out undesirable characteristics that ordinarily lie hidden in the genetic constitution of individuals. Such weeding out of the strains of weakness in a race may be desirable, as it leaves the remaining stock more uniform and healthy. This is the way that thoroughbred domestic stock has been originated and improved.

From these various studies, we may infer that if inbreeding were to occur in the bob-white population, there may be, at first a slight decrease in numbers due to the elimination of

individuals having unfavorable combinations of genetic characteristics, but that this would be followed by an increase and building up of a more healthy and vigorous stock. However, the striking fact is that there is no evidence that inbreeding occurs in the bob-white, nor that it is an important factor for consideration.

CAUSES OF FLUCTUATIONS IN ABUNDANCE.

Any one of several factors may be responsible in causing fluctuations in the number of birds. In the case of the bob-white, four factors have been singled out as of probable importance, namely, change in habitat (cover), occurrence of epidemic diseases, fluctuations in available food, and variations in climate. These factors may vary independently, but they produce a greater effect upon the bird when they combine and interact.

Leopold (1931) has stressed the great importance of cover to birds in the north-central states. Cover suitable for bob-white was much more abundant in the past than it is now, and he correlates this with a greater abundance of the species during the 19th century. Information is not available, however, to permit correlation between changes in cover and variations in abundance of the bird from one year to the next.

There is always the possibility that disease may be the active agent causing fluctuations in the abundance of a bird, although Stoddard (1931) found little evidence that disease was important with the bob-white in southern Georgia. Lack of food or the occurrence of severe weather may reduce the resistance of a bird to disease so that it may then become important.

During ordinary years there appears to be plenty of food available for the bob-white at all seasons, although late winter is a critical period. The bob-white selects its food from that which is most abundant, and, when it is able to find an adequate supply, is able to maintain its resistance and vitality (Errington, 1931, 1930).

The climatic factors which appear to be of particular importance are winter snowfall, summer rain, and temperature. Errington (1930, 1931) found that the bob-white is able to resist extremely low temperatures as long as food is available, but when snow covers the food supply, disaster results. Sleet storms and ice would have the same effect as snow in rendering

food unavailable. In our own studies with passeriform species (Baldwin and Kendeigh, 1932), we found that lack of food reduces a bird's resistance so that temperatures that are not exceptionally low become destructive. In discussing the mortality of bob-white, Leopold (1931) states that winter losses predominate in the northern tier of states and nesting losses in the southern. He believes that there is a direct killing of bob-white by climatic forces during severe winters, and that hard rains are destructive during the nesting season,

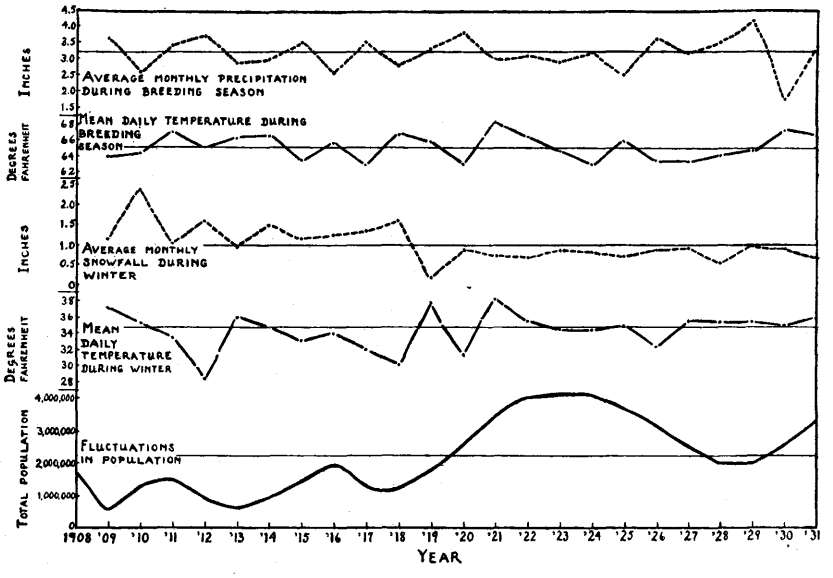

FIGURE 2. CORRELATION BETWEEN FLUCTUATIONS IN ABUNDANCE OF BOB-WHITE AND CLIMATIC FACTORS. The climatic factors considered here are average monthly precipitation and mean daily temperature during the breeding season (April, May, June, July, and August) and average monthly snowfall and mean daily temperature during the winter (November, December, January, February, and March). The narrow straight medium line running through each curve is the average value for the 23-year period (1909–1931).

particularly to young birds. Stoddard (1931) found that reproduction is usually higher and nesting mortality lower during dry seasons than during wet ones. Severe droughts are, however, unfavorable in Georgia because they reduce the percentage of eggs that hatch in nests that are placed on the hot parched ground.

With these points in mind, an attempt was made to correlate the fluctuations noted in the abundance of the bob-

white in Ohio with snowfall, summer precipitation, and mean temperature. The climatic data were compiled and averaged for the following localities from the Monthly Weather Review of the U. S. Weather Bureau: Cincinnati, Columbus, Dayton, Cleveland, Sandusky, and Toledo. In Figure 2, the average monthly snowfall and the mean daily temperature during the five winter months of November, December, January, February, and March, and the average monthly precipitation and mean daily temperature during April, May, June, July, and August are shown together with the curve of abundance of the bob-white. The effect of temporary periods of severe weather, lasting for a few days only, have not been analyzed in this paper.

The major point of significance in the curve of total annual populations (Figure 2) is the much greater abundance of the bob-white from 1919 to 1931 than from 1909 to 1918. An analysis of the curves for the four climatic factors indicates that this difference in the abundance of bob-white is most significantly correlated with a greater snowfall and a lower temperature during the winter for the earlier period. During the winter months from 1909 to 1918, inclusive, the snowfall averaged 1.41 inches per month compared with 0.76 inches per month from 1919 to 1931. The mean daily temperature during the winter was 33.6° F. for the earlier period and 35.0° F. for the latter. Since the species was given continuous protection from hunting beginning in 1913, this factor was not responsible for determining the lower numbers during the earlier period, although it may have been a contributing factor during the first four years.

The dip in the population curve during 1912–1913 is correlated with unusually severe conditions in 1912, when winter temperature was very low, snowfall high, and, in addition, heavy precipitation occurred during the breeding season. In 1913, climatic conditions ameliorated considerably, but this was not marked by an increase in number of birds. Apparently, other factors came into play this year which our data do not bring out.

The dip in the curve of bob-white abundance in 1917–1918 is correlated with falling winter temperature and increasing amount of snowfall becoming particularly severe during the latter year. Heavy precipitation and low temperature prevailed during the breeding season of 1917, but improved in 1918.

The last big depression in the abundance curve, beginning in 1925 or 1926 and culminating in 1929, is not correlated in these data with severe winter conditions but appears to be most significantly related with high precipitation during the summer season, this being combined with summer temperatures persistently lower than normal.

The rise in the curve of bob-white populations in 1910–1911 is not marked by particularly favorable climatic conditions. Snowfall was heavier in 1910 than in any other year, but this was apparently compensated for by the high average temperature which prevailed. The winter of 1911 had less snow, but the temperature averaged lower. It may well be that neither heavy snowfall nor low temperature during the winter is particularly effective in reducing the number of bob-white except when these conditions occur together. This they did during the following year of 1912, and then there appeared a decrease in birds.

There is little to mark the years of 1915 and 1916 when an increase in bob-white is noted. Climatic conditions were not particularly favorable nor markedly severe. The closing of the hunting season for bob-white during these years may well be responsible for the increase in numbers of birds noted.

The long upward trend in abundance of bob-white reaching the peak numbers in 1923 and 1924 was given a good impetus in 1919 by unusually favorable winter conditions and moderate breeding ones. During 1920, the climate was less favorable. The winter was cold, although the amount of snow was very moderate. During the summer, low temperatures were combined with heavy precipitation. It is quite possible that a minor fluctuation in abundance occurred this year, but does not show in our data. The following year, 1921, was again very favorable climatically, probably one of the best during the entire 24-year period. The following four years were moderate.

The long downward trend in abundance of bob-white beginning in 1925 was stopped abruptly and given an upward curve again in 1930. This latter year was marked by a moderate winter and a warm, very dry summer. The upward trend in numbers persisted in 1931, and there is every reason to suppose that it was again augmented in 1932.

Summarizing the correlations between climate and population trends in the bob-white that have been noted, it appears

that severe winters marked by low temperatures combined with heavy snows are generally disastrous to the species and will greatly reduce it in numbers. Unfavorable climate during the breeding season, i. e., heavy rains and low temperatures, acts less precipitously upon the numbers of birds, but will reduce the population by affecting the amount of reproduction.

It is worthwhile to note here that the positive correlation that has been made between climate and trends in population of bob-white not only brings out the importance that climate has in affecting the numbers of birds but also substantiates, to some extent at least, the general fluctuations noted in the population trends themselves.

MORTALITY.

Errington (1930, 1931), who has kept large numbers of coveys under observation throughout winter seasons, found a mortality of less than 7% during one winter that was mild and almost snowless. During another winter, he found a mortality of 30%, as a consequence of severe cold and heavy snow during January.

As the result of the severe winter of 1912 followed by a none too favorable breeding period, there was a decrease of 40% in the bob-white population of Ohio. In 1917 and 1918, cold, snowy winters were followed in 1917 by unfavorable climate during the breeding season but by favorable climate during the breeding season of 1918. This corresponds with a decrease in population of birds amounting to 33% over what it was in 1916. The winter of 1918 was more severe than in 1917, but this was apparently offset by a more favorable breeding period.

During what appears to have been moderate winters but unfavorable breeding periods from 1926 to 1929, inclusive, there was an average decrease in total population of 14% per year. This means that the reproduction of the species during these years enabled it to compensate very little if any for the normal rate of mortality of the old birds even during years when the old birds were not subjected to particularly severe winter conditions.

RECUPERATIVE POWERS.

The reproduction of bob-white must fully compensate for the annual rate of mortality of adult birds even during favorable years, if the population is to remain constant. If an

increase is to occur in the number of individuals, not only must this be done, but also a surplus of young must be raised. During the 12 years in this record when an increase in population was noted, this surplus has amounted, on the average, to 39% of the previous year's numbers. If the figure of 14%, given above, be assumed as representing somewhere near the normal rate of dying off of adult birds under favorable climatic conditions, then the total recuperative powers of the bob-white under favorable breeding conditions would be approximately 53%. In other words, a pair of adult bob-white is able to raise about one bird to maturity, on the average, during favorable years. This figure needs to be checked by more intensive field study, but furnishes a preliminary figure with which to work. An unfavorable year, therefore, that causes a loss of birds amounting to 33–40% of the previous number will not be fully compensated for until the second favorable season for reproduction.

METHODS FOR INCREASING ABUNDANCE.

The bob-white is not so abundant as is desirable if the greatest possible benefit is to be derived from its presence in the State. After severe winters or unfavorable breeding seasons the species may be very scarce. How may the number of bob-white in the State be increased?

The devastating action of severe winter weather may be mitigated locally by providing food artificially. Errington (1930, 1931) recommends the leaving of isolated shocks of corn near favorable habitats of bob-white. The artificial feeding of the entire population throughout the State during unfavorable years seems impractical, without the ardent and enthusiastic co-operation of the entire farming population. This will require considerable in the way of an educational policy. The farmer holds the control in all measures that are designed to permanently increase the number of bob-white, and unless his co-operation is solicited, all these measures of conservation will fail.

Leopold (1931) is working on a method of game management in states where hunting is permitted. He suggests that the farmer consider the natural breeding and protection of bob-white on his farm as a crop to be actively encouraged, and that remuneration be sought from levies on sportsmen who desire to hunt on his property.

For increasing the population of bob-white, the maintenance

of a proper habitat for shelter and food is an absolute prerequisite. Unless food is available in abundance at all seasons of the year with the proper shelter from enemies, any artificial means of multiplying the number of bob-white is futile. If the proper habitat is available or can be increased in extent, the bob-white will ordinarily increase in abundance on its own natural resources until the saturation point is reached.

The natural habitat of the bob-white consists of open woods, with plenty of shrubs and grass, shrubby and grassy fields, fallow fields, shrubby fence rows, and thickets adjacent to open land. Such habitats could be readily encouraged by farmers if the desirability of doing so were effectively brought to their attention. The bob-white must have suitable cover to furnish it with shelter from enemies, shelter from climatic elements, and as a location for placing and hiding the nest. The bird seldom wanders far from shelter of some sort. The flight of the bird is swift and powerful for short distances but cannot be maintained for long, so that shelter must be available within easy reach or the bird will be exposed to the attack of many predators. This cover can be created by the farmer with little or no loss to normal operations. Osage-orange hedge-rows are very favorable, or, if these are not practical, the allowing of wild shrubbery and briars to develop along fence rows, fence corners, farm lanes, or other out-of-the-way places will well serve the purpose. If semi-open woodlots, river bottoms, hilly areas, or other areas unsuitable for crops are available, the bob-white will flourish if the natural growth of thickets is not prevented and grazing by domestic stock is not intense. Stoddard (1931) and Leopold (1931) discuss many practicable features in adapting farm country to bob-white.

Attempts have been made from time to time to introduce into northern states a bob-white (*Colinus virginianus texanus*) from Texas and Mexico to augment the native stock. According to Leopold (1931), 6,000 such birds were liberated in Ohio in 1916, but it is doubtful if many of these survived. Introduction of these foreign birds is not to be recommended because the southern bob-white is of less vigorous stock, weighs less, and is less resistant to northern winters. By interbreeding with the native northern bob-white, it may readily undermine the vitality and natural hardiness of the entire population.

The practicality of raising bob-white artificially for liberation is a question. This has been successful in the case of a few

other species. At present, the cost of hatching bob-white in incubators or under hens and raising the chicks to maturity is too prohibitive for extensive liberation purposes. However, methods are now under investigation, and it is not unlikely that in the near future, the total expense of raising a pair of adult birds will be materially reduced. There is no reason to believe that artificially reared birds will be any more resistant to cold, heat, snow, lack of food, rain, and droughts than is the native stock. Therefore, there is the chance that a large proportion of any such release of artificially reared birds might be destroyed within a few months.

Even if the artificial rearing and liberation of bob-white may some day become practicable, this undoubtedly could not be done extensively enough to furnish birds directly for hunting. Such birds will best serve the purpose of adding to the breeding stock, as the maximum increase in population would have to be brought about by natural production. However, there is no value in liberating birds except into areas having suitable habitats to receive them. Without abundant food and shelter, they would not long survive.

The whole problem of increasing the population of bob-white reduces down to the establishment and expansion of habitat areas containing suitable cover and food. The preceding study of the fluctuations in the population of bob-white during the last 24 years indicates that, where given proper protection and habitat and when the climate is favorable, the species is capable of rather rapidly increasing its numbers by natural reproduction. With the increase in abundance, the birds must of necessity expand their areas and spread into new and favorable regions. It seems, therefore, that if new habitats for the bird are formed, natural reproduction will soon enable the species to fill in these areas without the necessity of liberating either imported birds or those that have been reared artificially. If, however, local areas of considerable size are found in the State in which no breeding stock is present, the liberation there of artificially reared native stock to serve as a nucleus for breeding purposes may be desirable; or birds in *nearby* localities may be trapped and imported.

RECOMMENDATIONS AS TO CONSERVATION.

In southern Georgia, Stoddard (1931, page 341) states that on some places it is safe to shoot approximately 25% of the

population of bob-white annually, where control of natural enemies is fairly adequate. On very large tracts of preserved land, as where several estates are located in a group and the owners are co-operating in the control of the enemies of the bob-white, it may be possible ultimately to harvest up to 50% of the crop and still leave a sufficient breeding nucleus. On other areas, no surplus is produced for hunting. Leopold (1931, page 87) states that an annual kill of 50% of the population is, at present, unsafe in the northern states, and indicates that 33% is about the maximum from which the species can recover during favorable years.

It is absolutely essential if the population of bob-white is not to be depleted that no more birds die each year than are raised, whether their death be due to natural causes or to hunting. Our population data for bob-white in Ohio, indicate, as was discussed above, that during favorable years, an average increase of 39% of the previous year's population occurs. This represents the maximum number available for hunting purposes during the 12 years in which a surplus of birds was produced. During the other 12 years in this period, the number of birds remained the same or there was a decrease in abundance. During these years, no birds at all would have been available for hunting.

If, 2,400,000 birds be taken as the average bob-white population for the State and 39% of these are available to the hunter during favorable years, this amounts to approximately 936,000 that may be killed. According to information kindly obtained for us by the Ohio Division of Conservation, there have been over 400,000 hunting licenses given out during each of the last four years. All of these licenses stand for potential hunters of bob-white. The total number of birds available for these 400,000 hunters would average about 2⅓ birds apiece for the season. This number is so small as to make the hunting of this species an impractical one for sport, even if such a small bag limit could be enforced.

The gravest danger lies, however, in possible extermination of the species in the State during those years when no increase or surplus is produced due to unfavorable breeding conditions, or when the number of breeding pairs have been reduced due to severe winter conditions. The killing by hunters of 936,000 birds during a single year would have wiped the species entirely out of existence in Ohio in 1909, 1912, and 1913 and nearly so

in 1914. A similar kill in 1917 or 1918 would have so reduced the number of birds left for breeding that recovery would have been insufficient to permit the species to survive the hunting season of the following year. Similarly, if hunters had killed 936,000 birds per year during the period beginning in 1926 when the bob-white population was decreasing from natural causes at the rate of 14% per year, the species would have been exterminated in the State by 1928. It is against this danger that the people in Ohio must guard, since it has been demonstrated above that the species is of interest not only to the hunter but also to the farmer and to the bird lover, and their interests must be considered.

The conclusion must be, therefore, that the population of bob-white in Ohio is *not* of sufficient size to permit a *general* open hunting season throughout the State. If hunting is to be permitted at all, it must be confined to local areas where the bird is sufficiently abundant to withstand the drain upon its numbers, where the amount of hunting may be carefully controlled, and where protection and food may be furnished during periods of stress.

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